

KamLAND, LBNL, and the New Neutrino Revolution

Jason Detwiler

General Science Area Meeting
LBNL
April 10, 2009

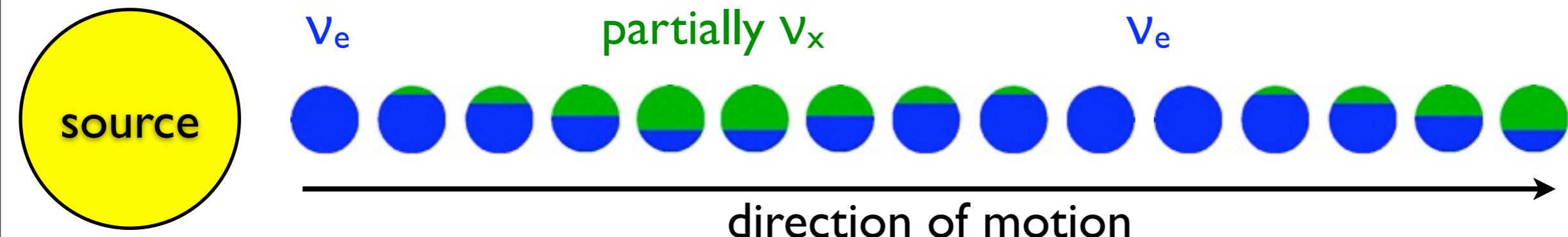


KamLAND: an update

Jason Detwiler

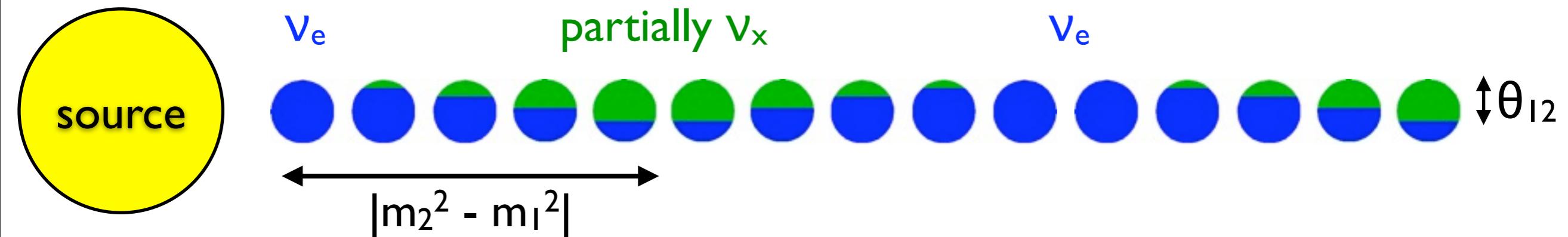
NSD Monday Morning Meeting
April 13, 2009

Neutrino Mixing and Oscillation



$$\nu_e = \cos \theta_{12} \nu_1 + \sin \theta_{12} \nu_2$$

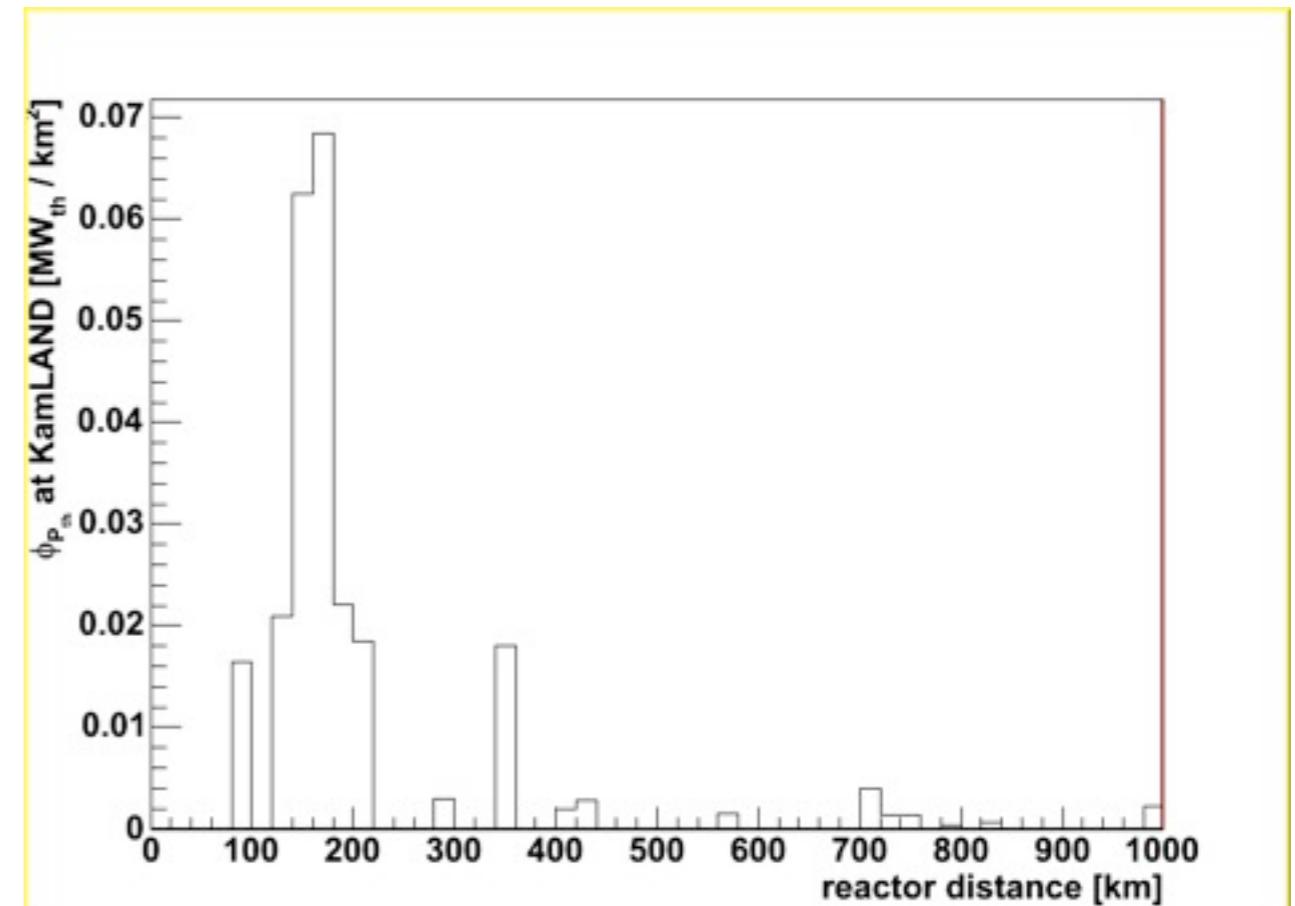
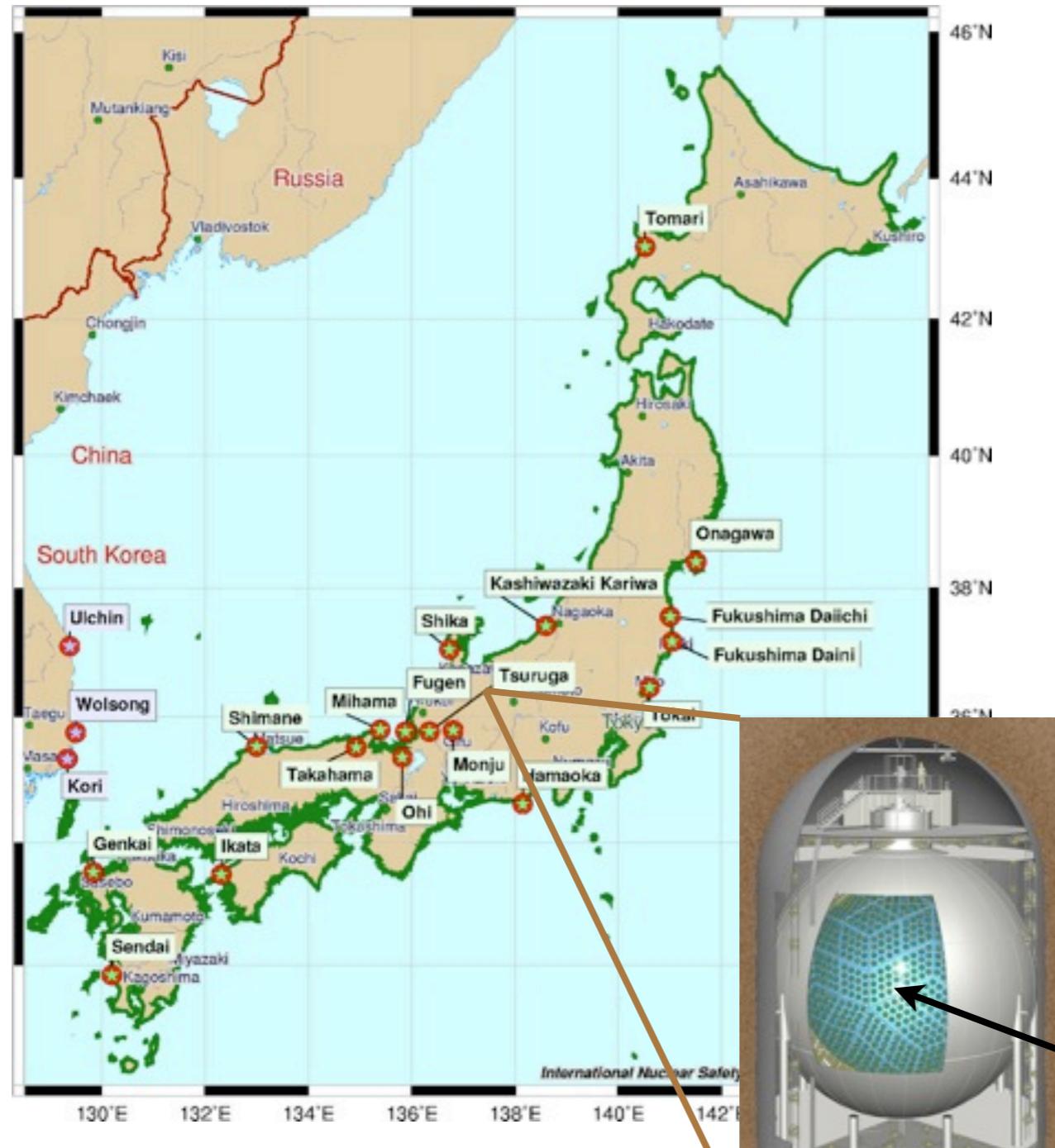
Neutrino Mixing and Oscillation



$$\nu_e = \cos \theta_{12} \nu_1 + \sin \theta_{12} \nu_2$$

$$P(\nu_e \rightarrow \nu_e, L) = 1 - \sin^2 \theta_{12} \sin^2 \left(\frac{\Delta m_{21}^2 L}{4E} \right)$$

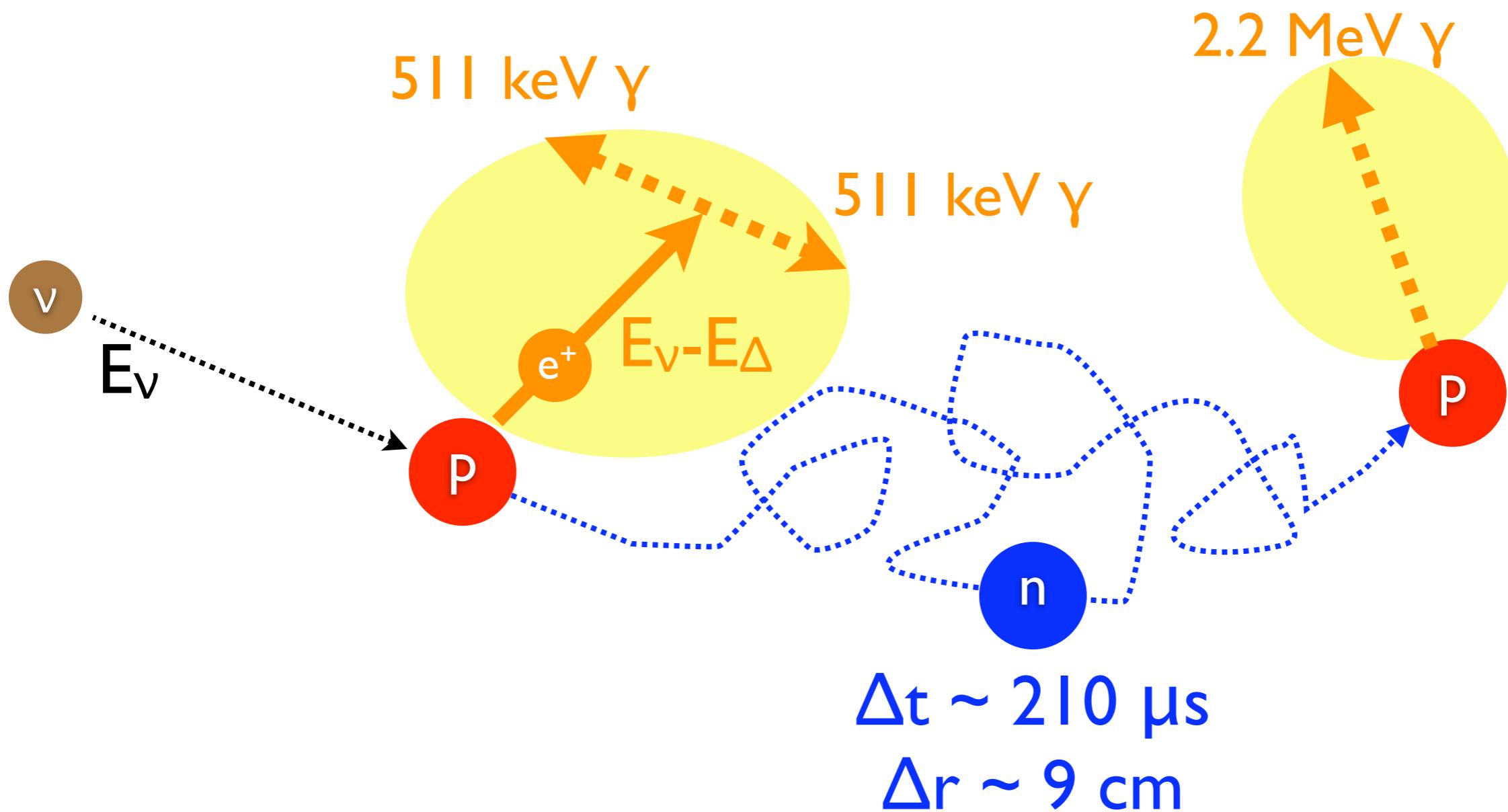
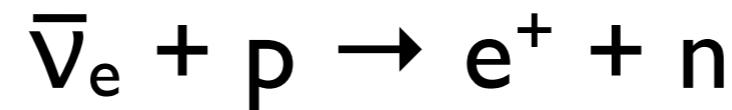
KamLAND



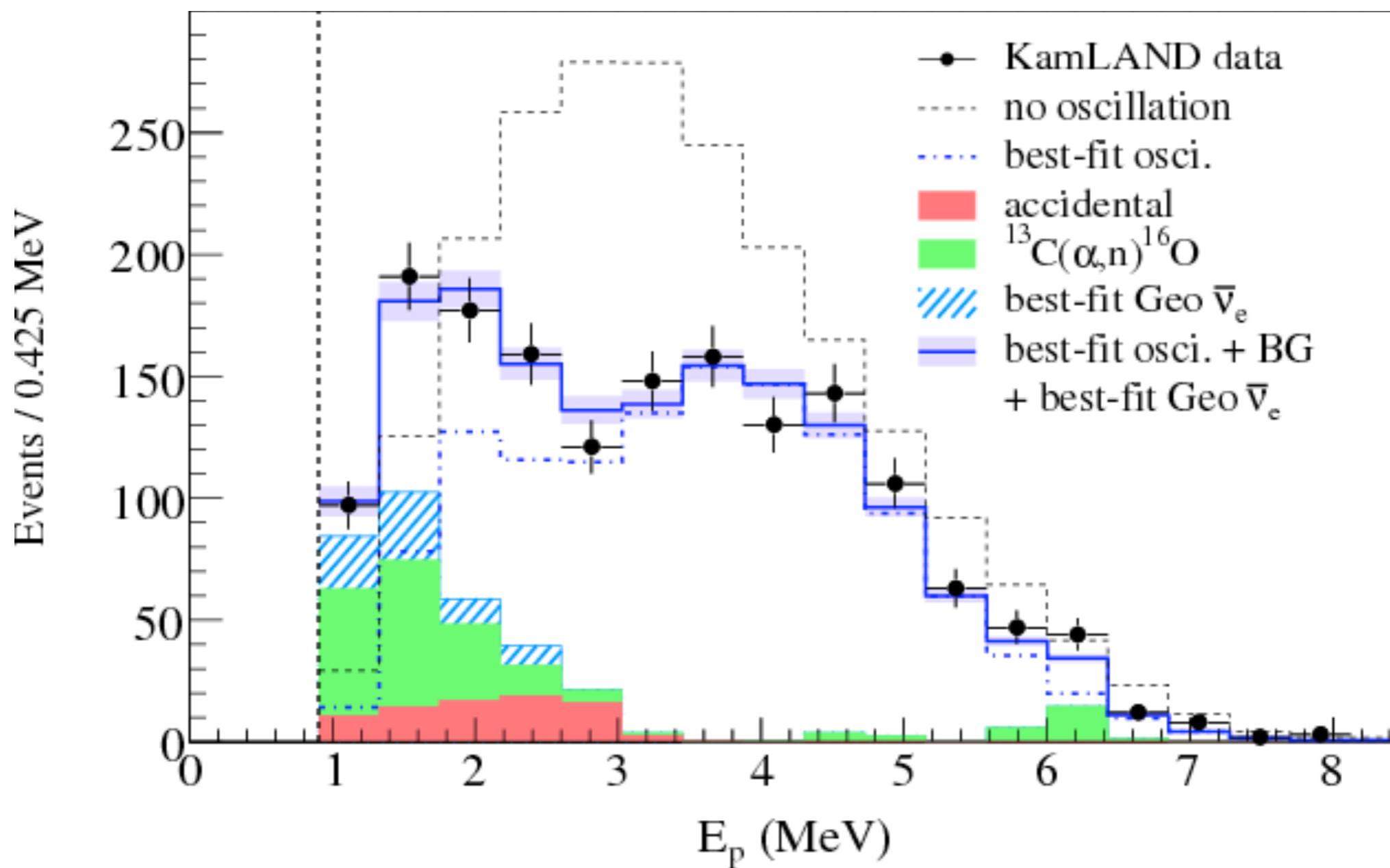
80% of total flux from
baselines 140-210 km

~1 kton liquid scintillator

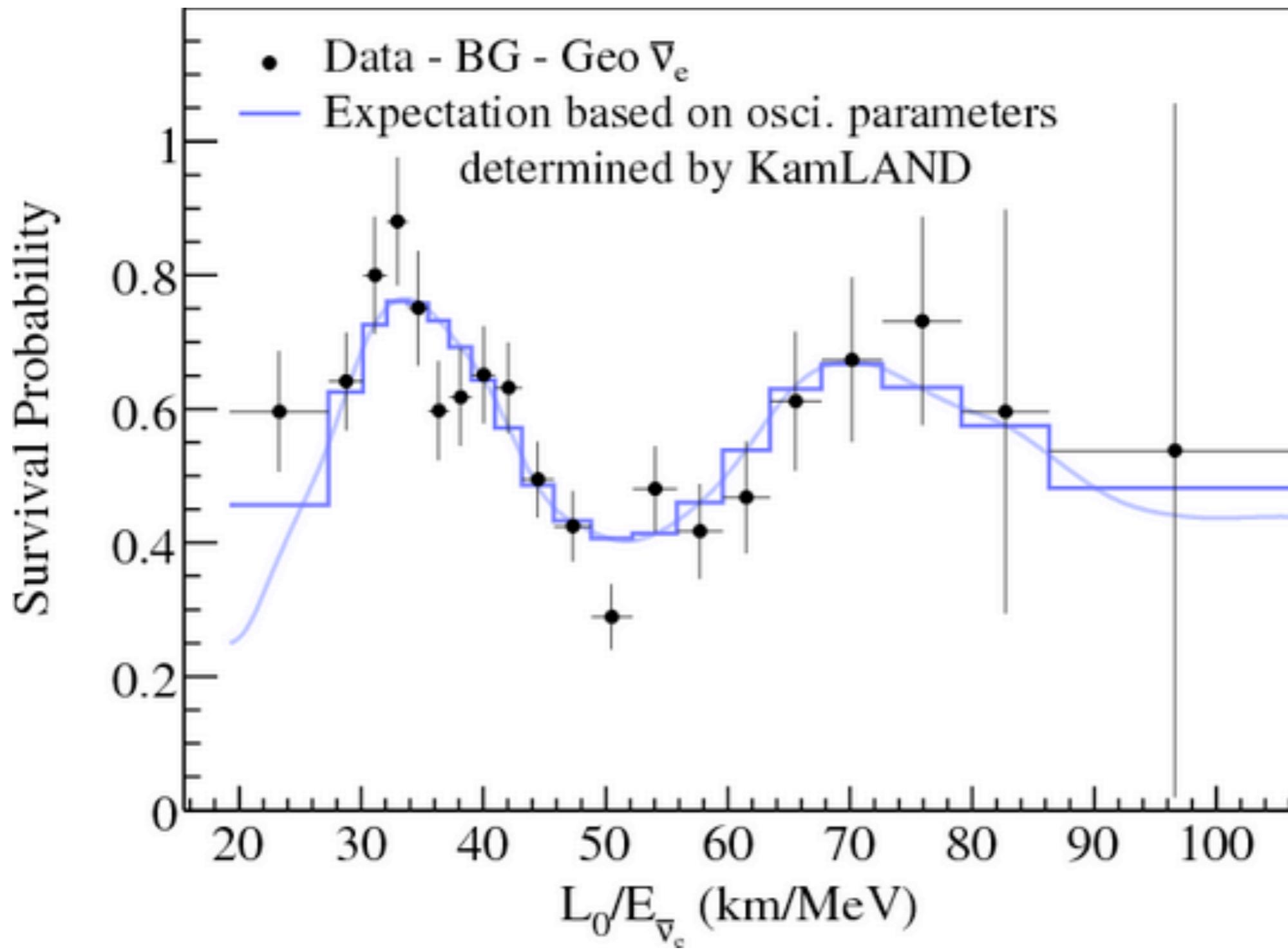
KamLAND



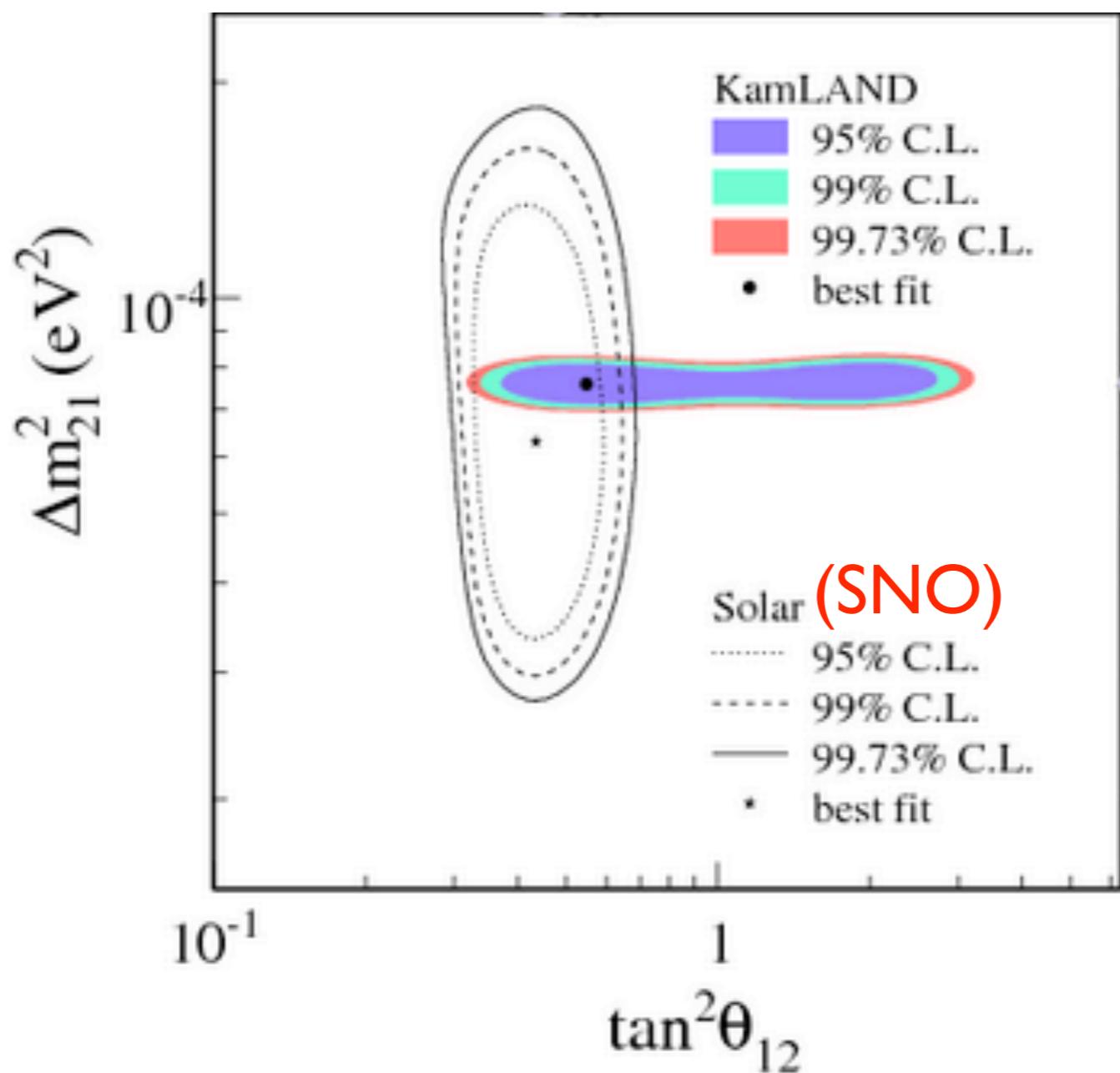
Reactor Neutrino Spectrum



Neutrino Oscillation



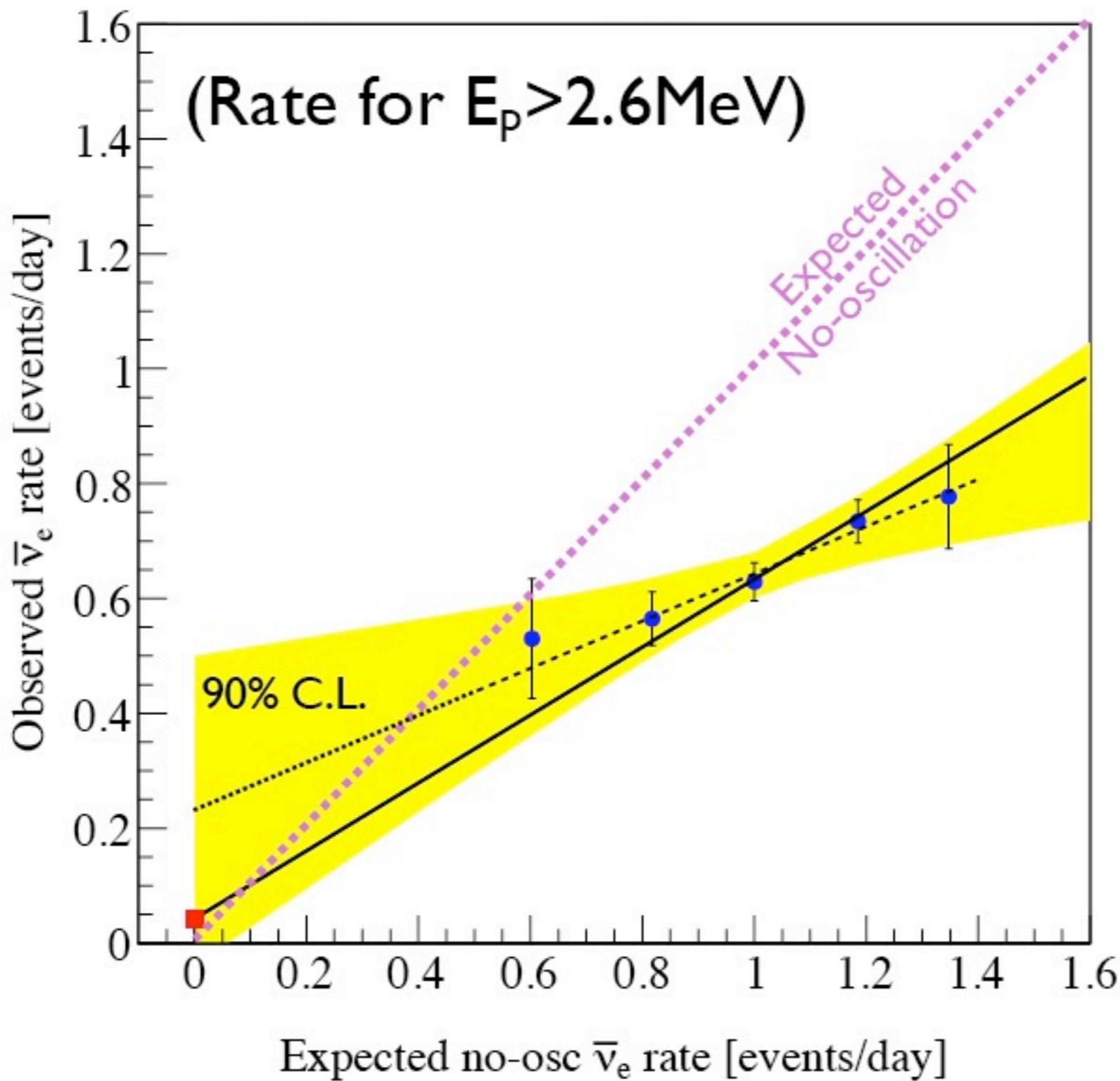
Neutrino Oscillation: Where We Stand



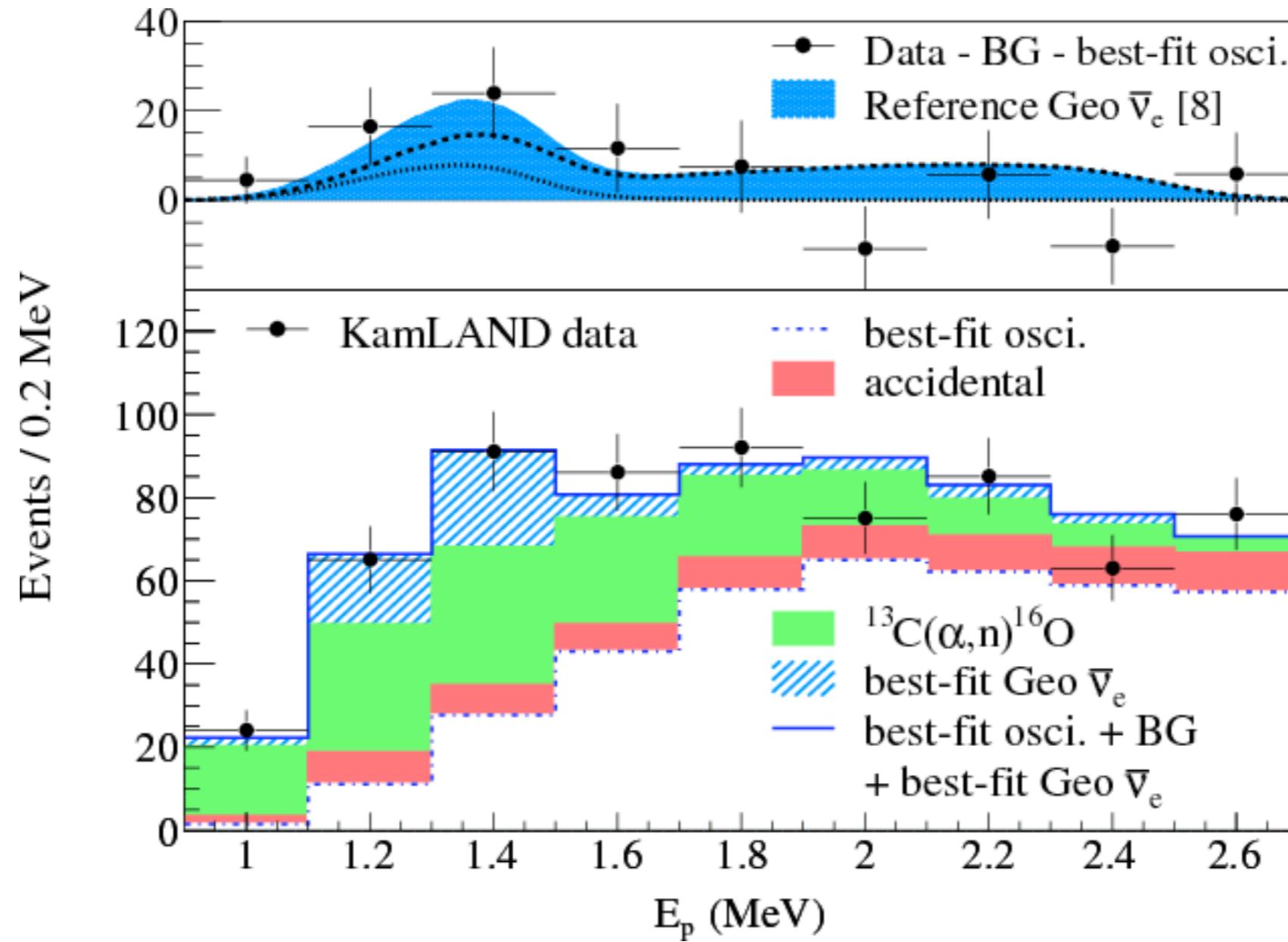
Systematic Uncertainties

	Detector-related (%)		Reactor-related (%)	
Δm_{21}^2	Energy scale	1.9	$\bar{\nu}_e$ -spectra [7]	0.6
Event rate (θ_{12})	Fiducial volume	1.8	$\bar{\nu}_e$ -spectra	2.4
	Energy threshold	1.5	Reactor power	2.1
	Efficiency	0.6	Fuel composition	1.0
	Cross section	0.2	Long-lived nuclei	0.3

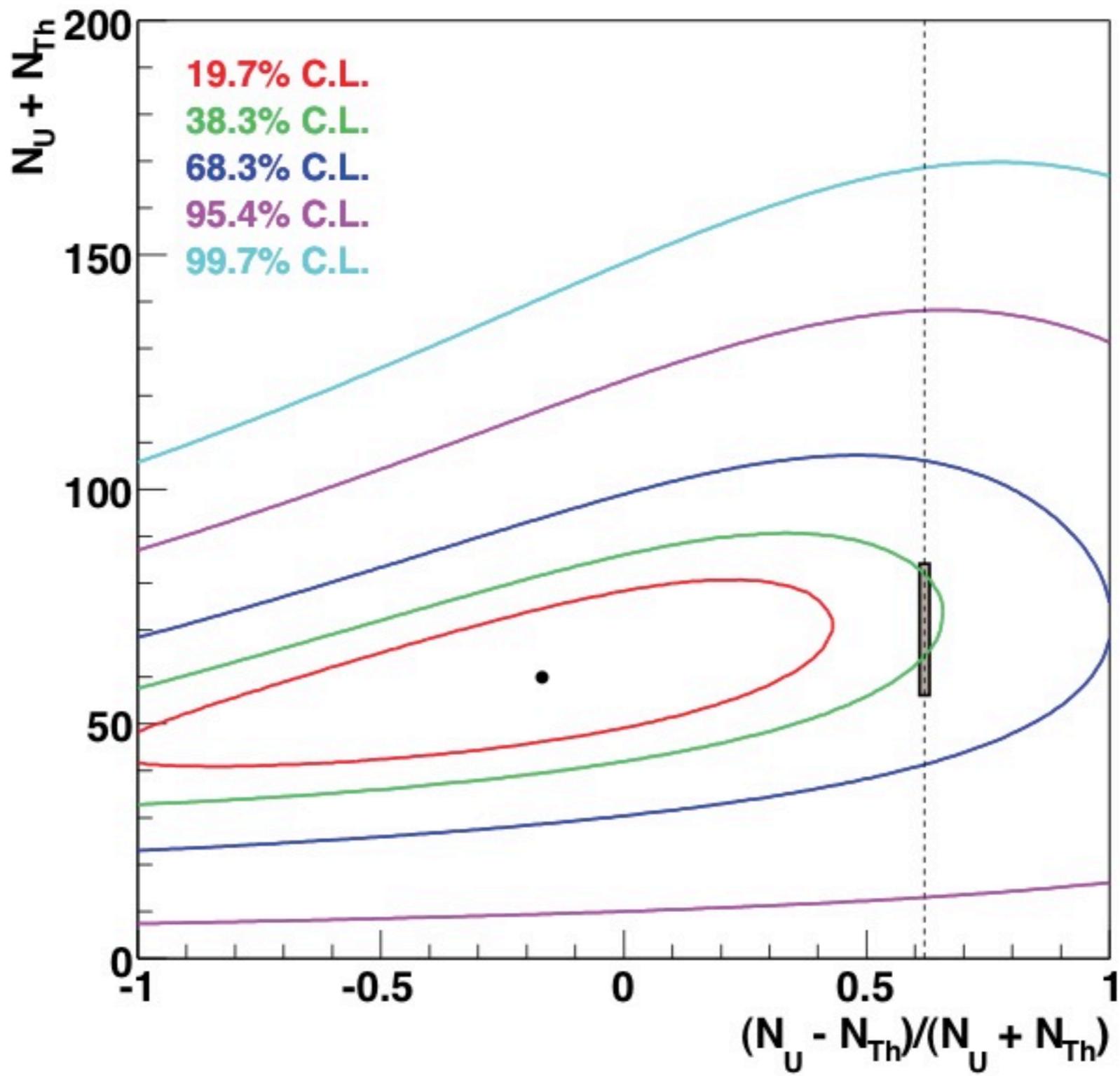
Time Variation



Geoneutrinos



Geoneutrinos



KamLAND Publications

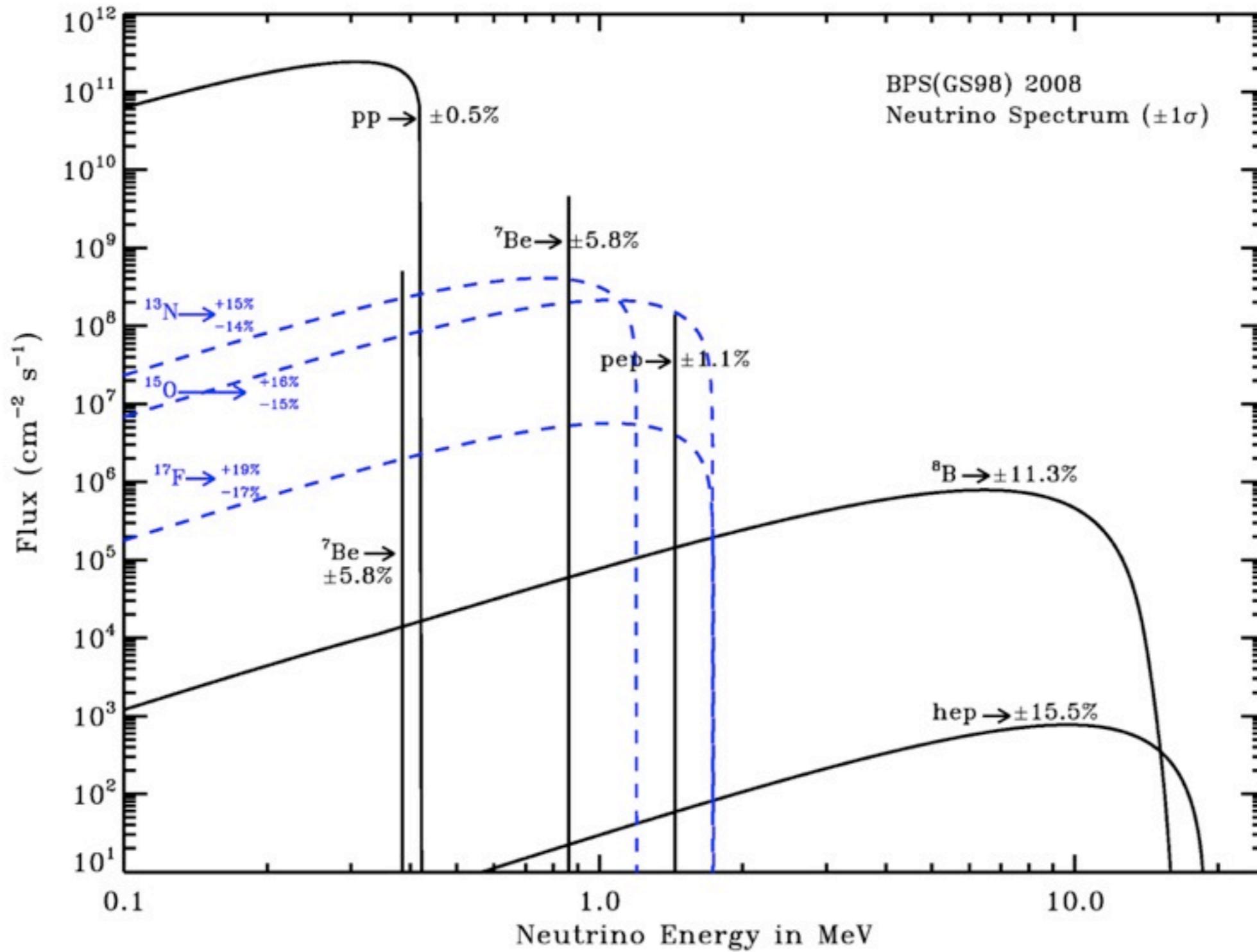
- reactor III • PRECISION MEASUREMENT OF NEUTRINO OSCILLATION PARAMETERS WITH KAMLAND, Phys. Rev. Lett. **100**, 221803 (2008)
- geo-v II • SEARCH FOR THE INVISIBLE DECAY OF NEUTRONS WITH KAMLAND, Phys. Rev. Lett. **96**, 101802 (2006)
- n decay • EXPERIMENTAL INVESTIGATION OF GEOLOGICALLY PRODUCED ANTINEUTRINOS WITH KAMLAND, Nature **436**, 499-503 (2005)
- geo-v I • MEASUREMENT OF NEUTRINO OSCILLATION WITH KAMLAND: EVIDENCE OF SPECTRAL DISTORTION, Phys. Rev. Lett. **94**, 081801 (2005)
- reactor II • A HIGH SENSITIVITY SEARCH FOR ANTI-NEUTRINO'S FROM THE SUN AND OTHER SOURCES AT KAMLAND, Phys. Rev. Lett. **92**, 071301 (2004)
- solar $\bar{\nu}_e$ • FIRST RESULTS FROM KAMLAND: EVIDENCE FOR REACTOR ANTI-NEUTRINO DISAPPEARANCE, Phys. Rev. Lett. **90**, 021802 (2003)
- reactor I •

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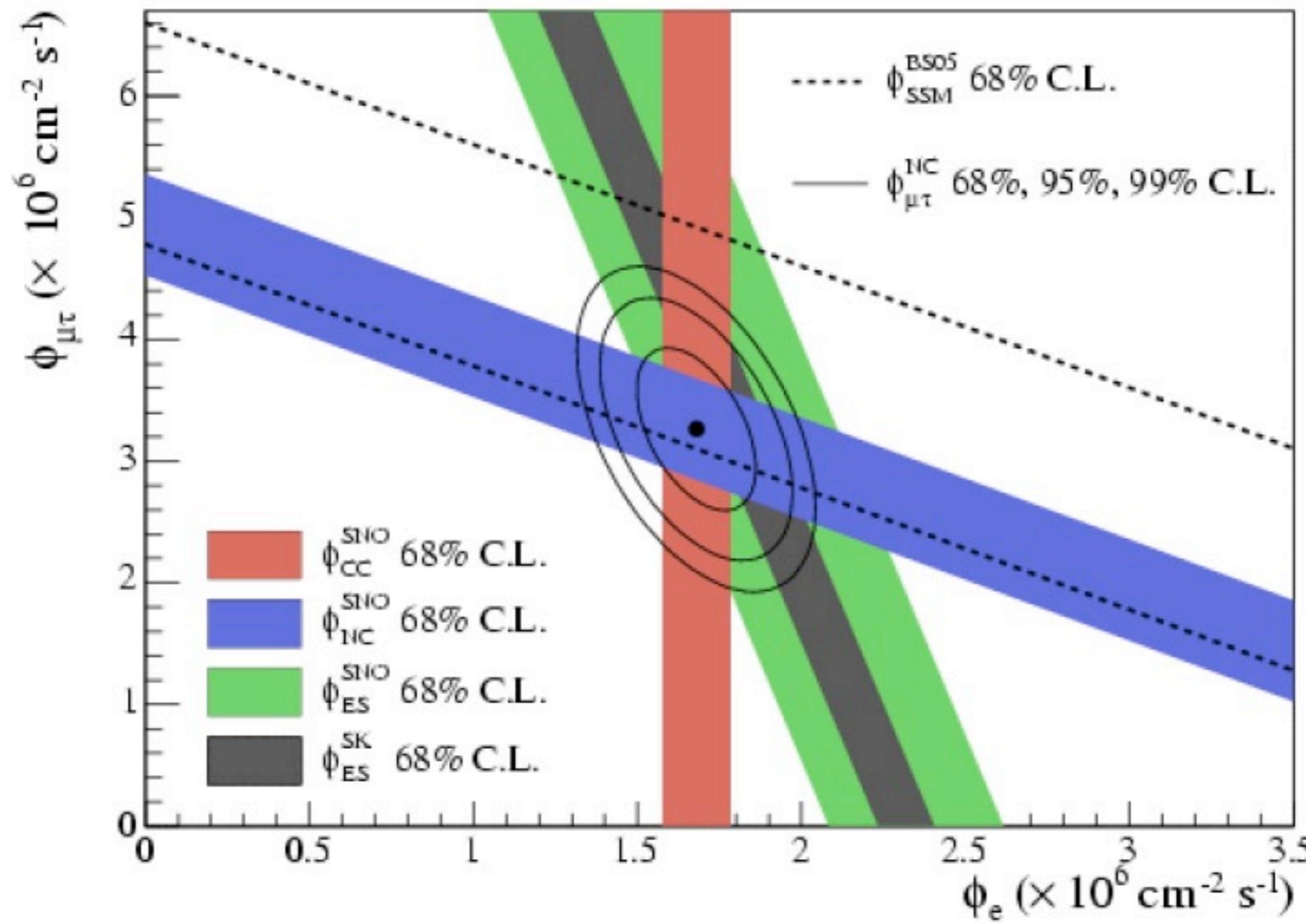
The Red Hot Research Papers of 2003

Rank	Paper	Cites
1	A.L. Spek, "Single-crystal structure validation with the program PLATON," <i>J. Appl. Cryst.</i> , 36: 7-13, February 2003.	204
2	K. Eguchi, et al., "First results from KamLAND: Evidence for reactor antineutrino disappearance," <i>Phys. Rev. Lett.</i> , 90(2): 1802, 17 January 2003.	157
3	J.S.M. Peiris, et al., "Coronavirus as a possible cause of severe acute respiratory syndrome," <i>Lancet</i> , 361(9366): 1319-25, 19 April 2003.	135

Solar Neutrinos



SNO/SK ${}^8\text{B}$

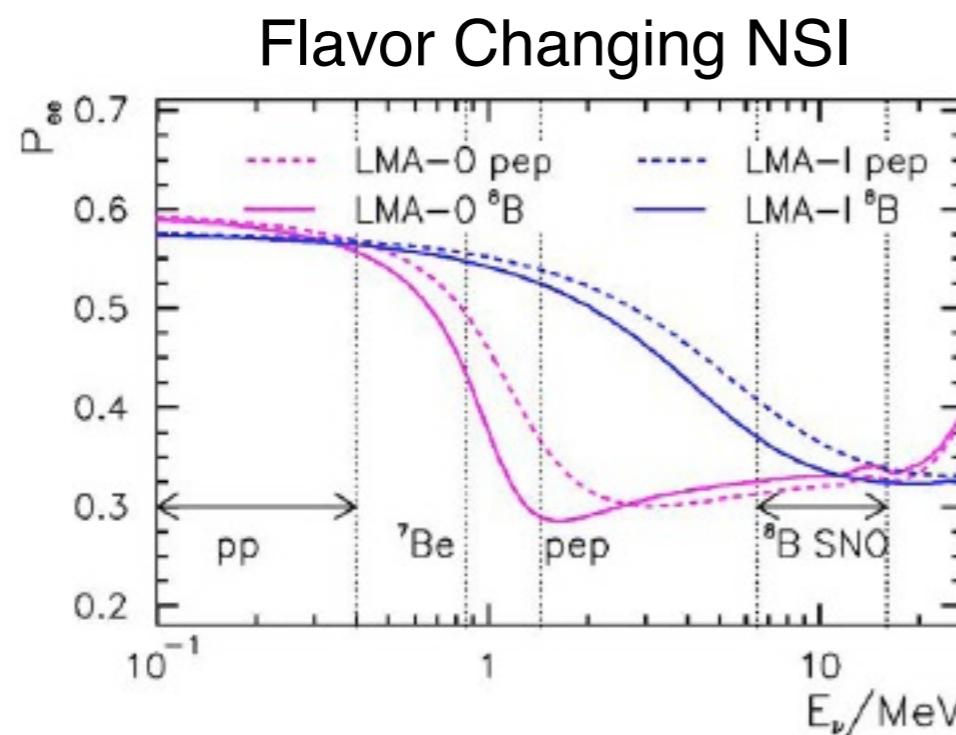
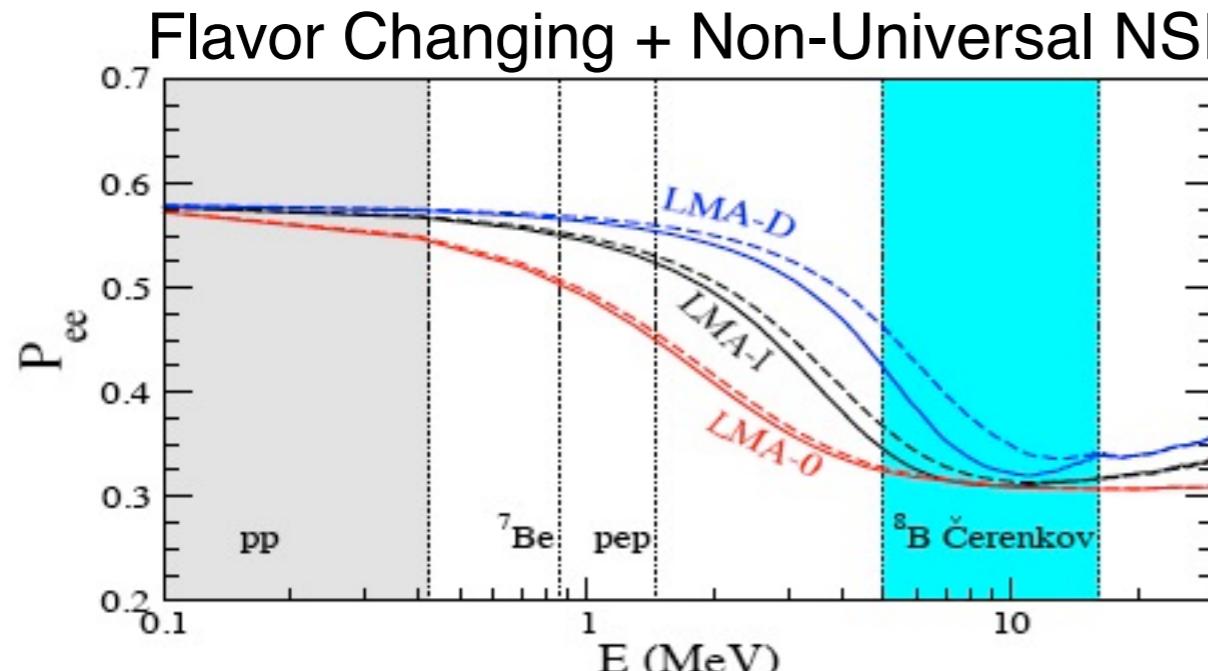


The SNO Collab., Phys. Rev. C **72**, 055502 (2005)

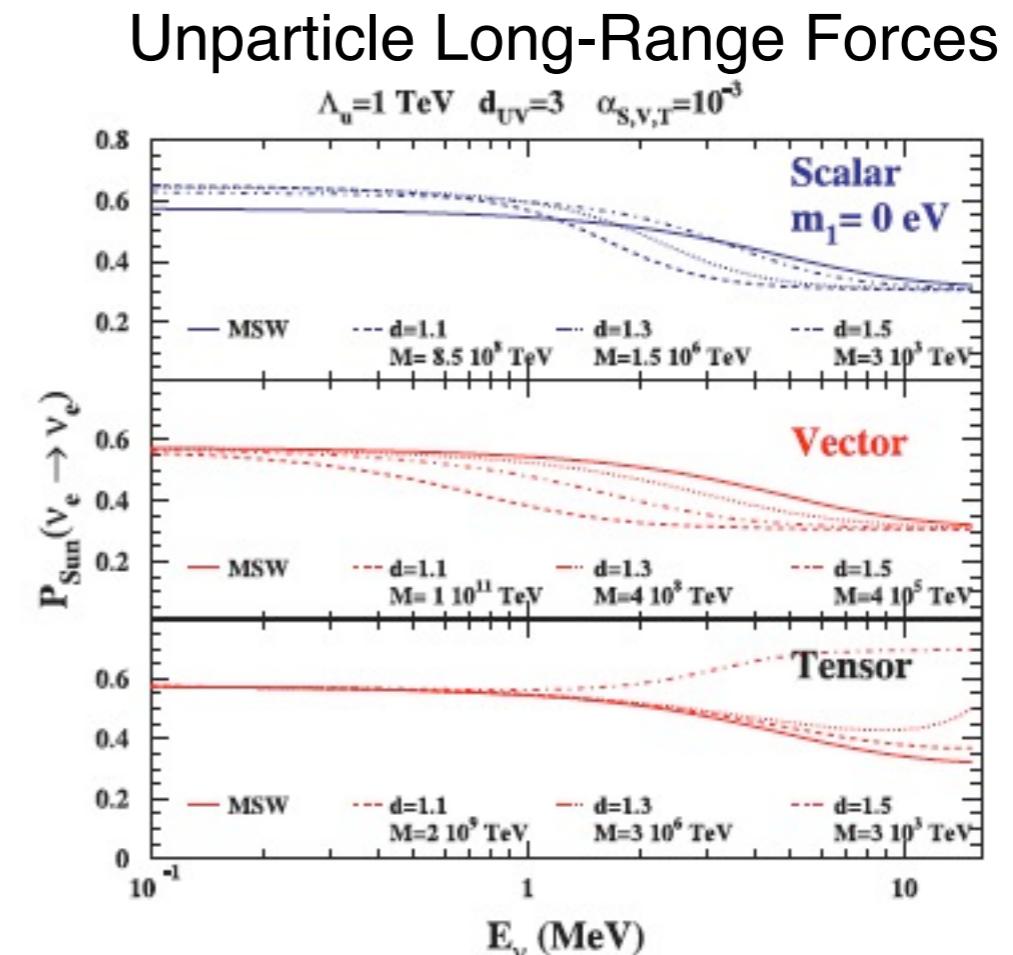
Testing the Standard Solar Model

- ${}^7\text{Be}$ flux is 1000 times that of ${}^8\text{B}$ - gives a much better measure of the sun's ν luminosity
- Mono-energetic ${}^7\text{Be}$ ν originate deeper in the sun and have a unique oscillation pattern - highly complementary to ${}^8\text{B}$, sensitive to non-standard neutrino interactions
- CNO flux is sensitive to the core metallicity, current measures of which contradict highly precise helioseismology measurements

Non-Standard ν Interactions

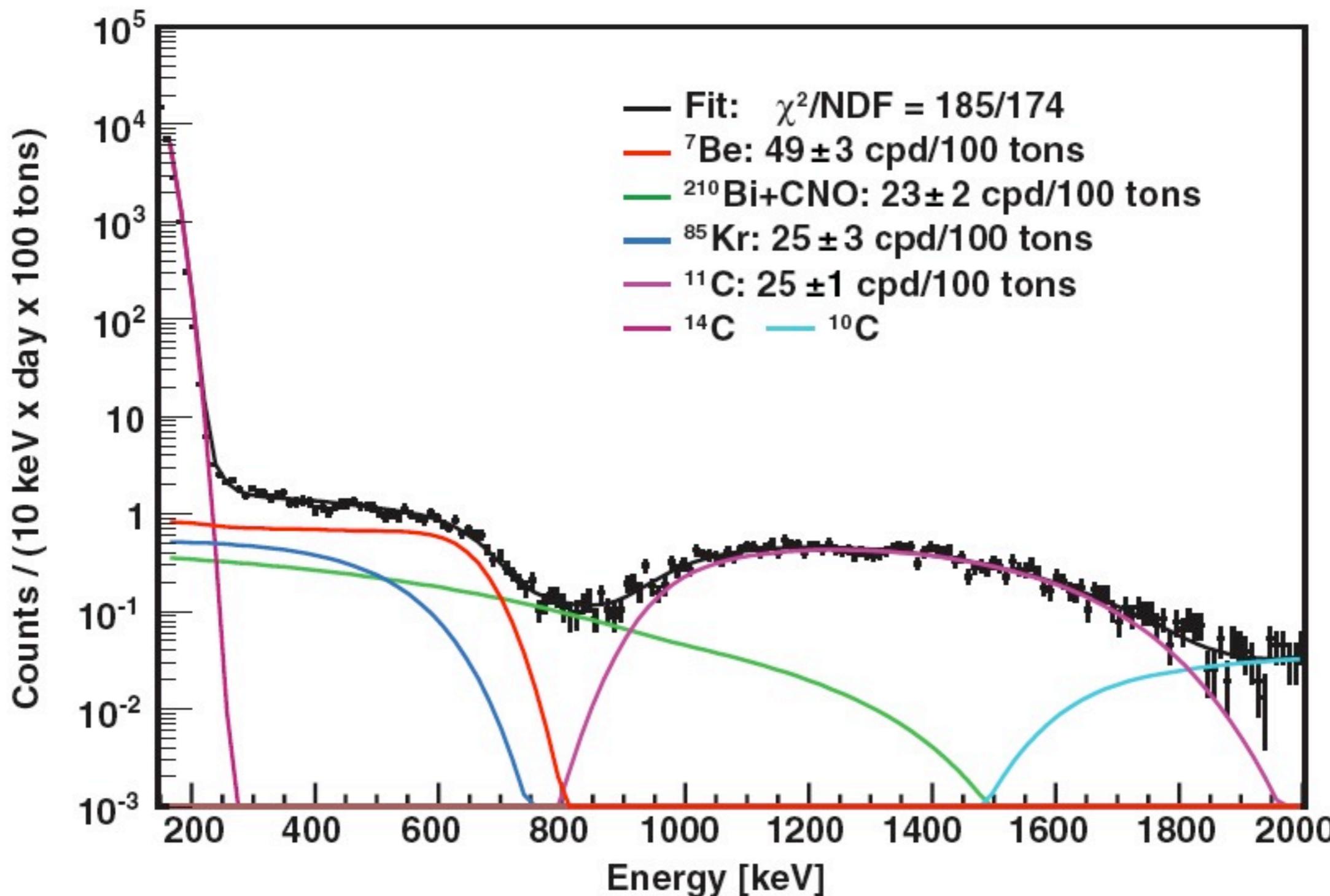


Friedland, Lunardini, Peña-Garay,
Phys. Lett. B 594, p347 (2004)



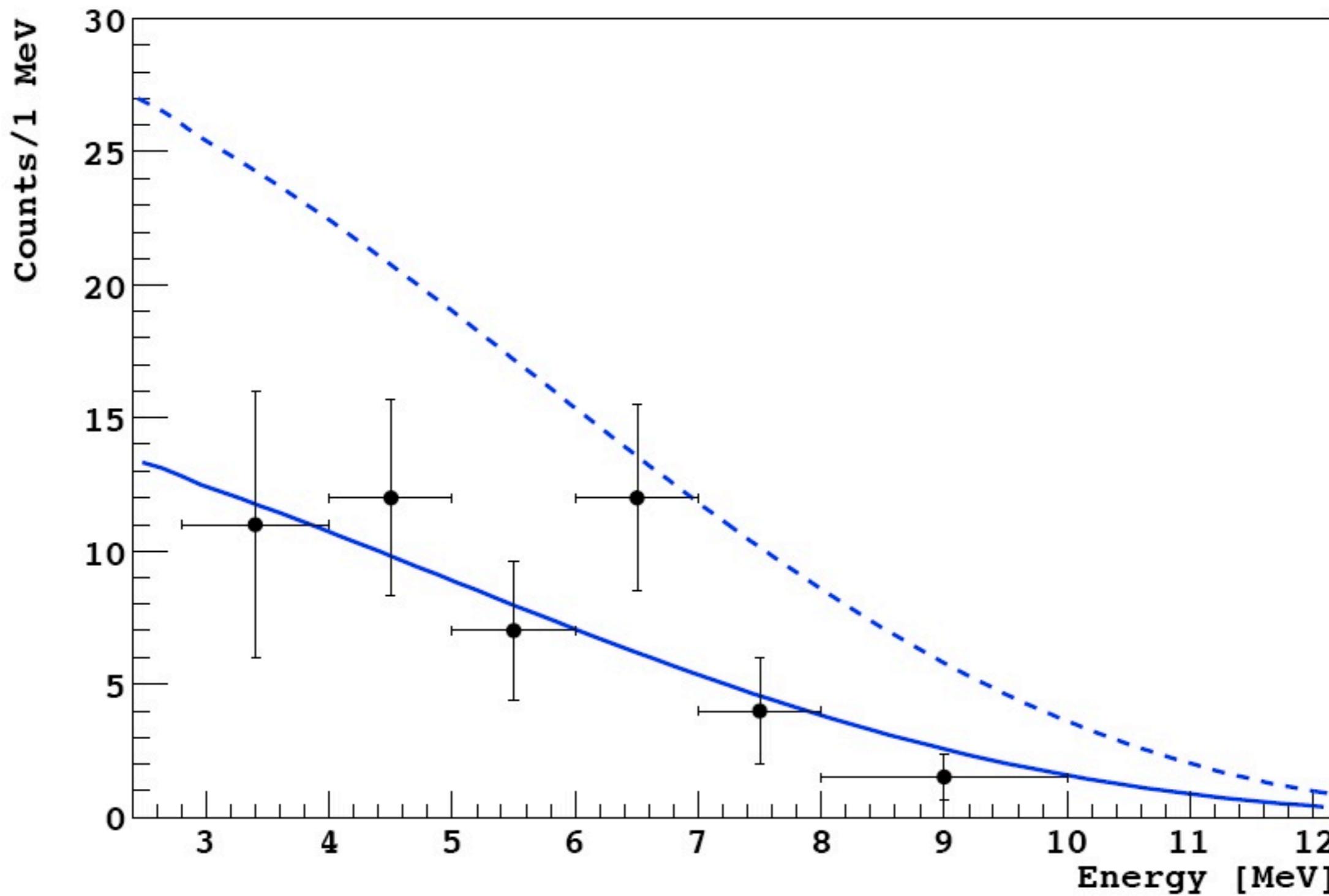
Gonzalez-Garcia, Holanda, Funchal
JCAP 06, 019 (2008)

Borexino ^7Be & CNO



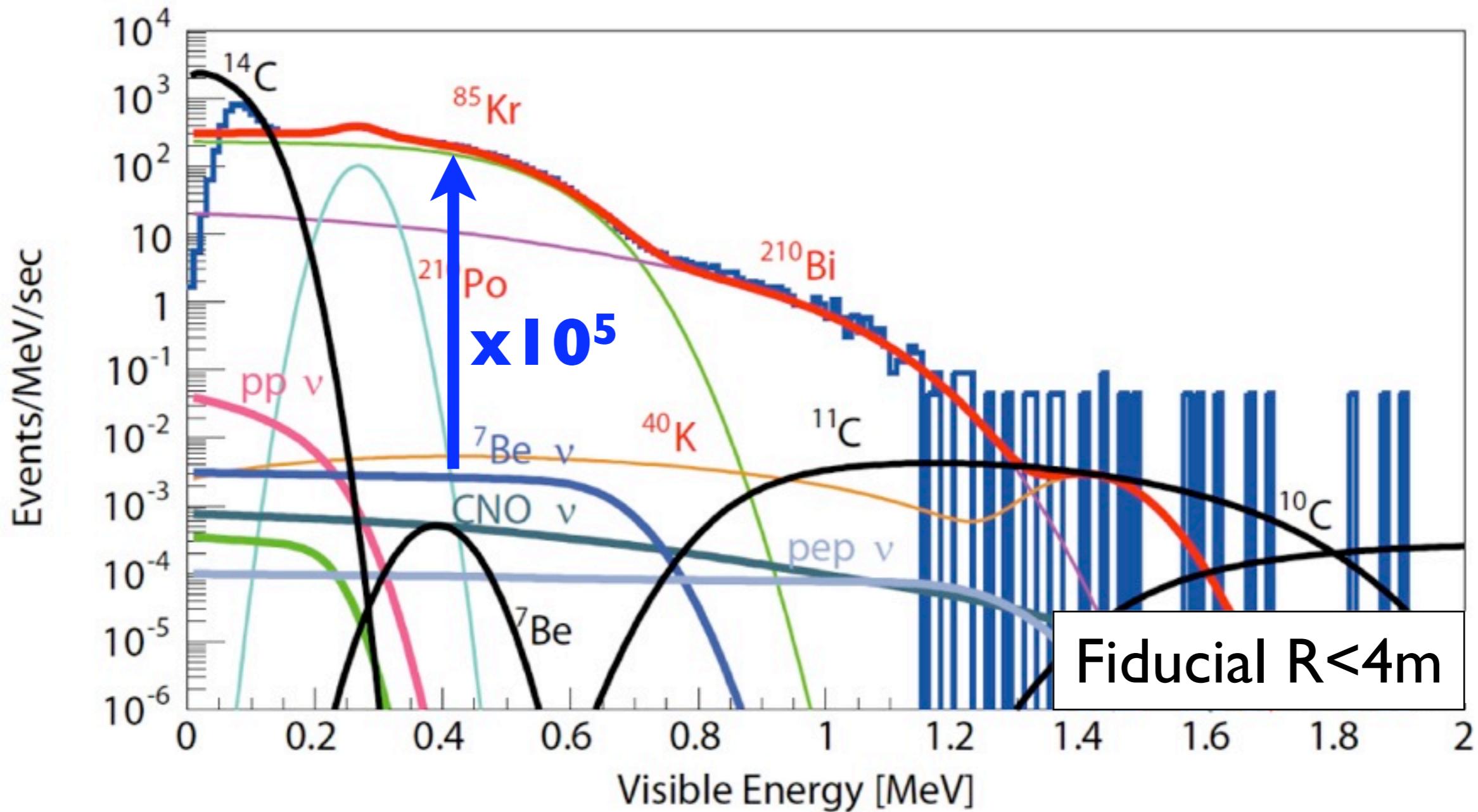
The Borexino Collaboration, Phys. Rev. Lett. **101**, 091302 (2008)

Borexino ${}^8\text{B}$

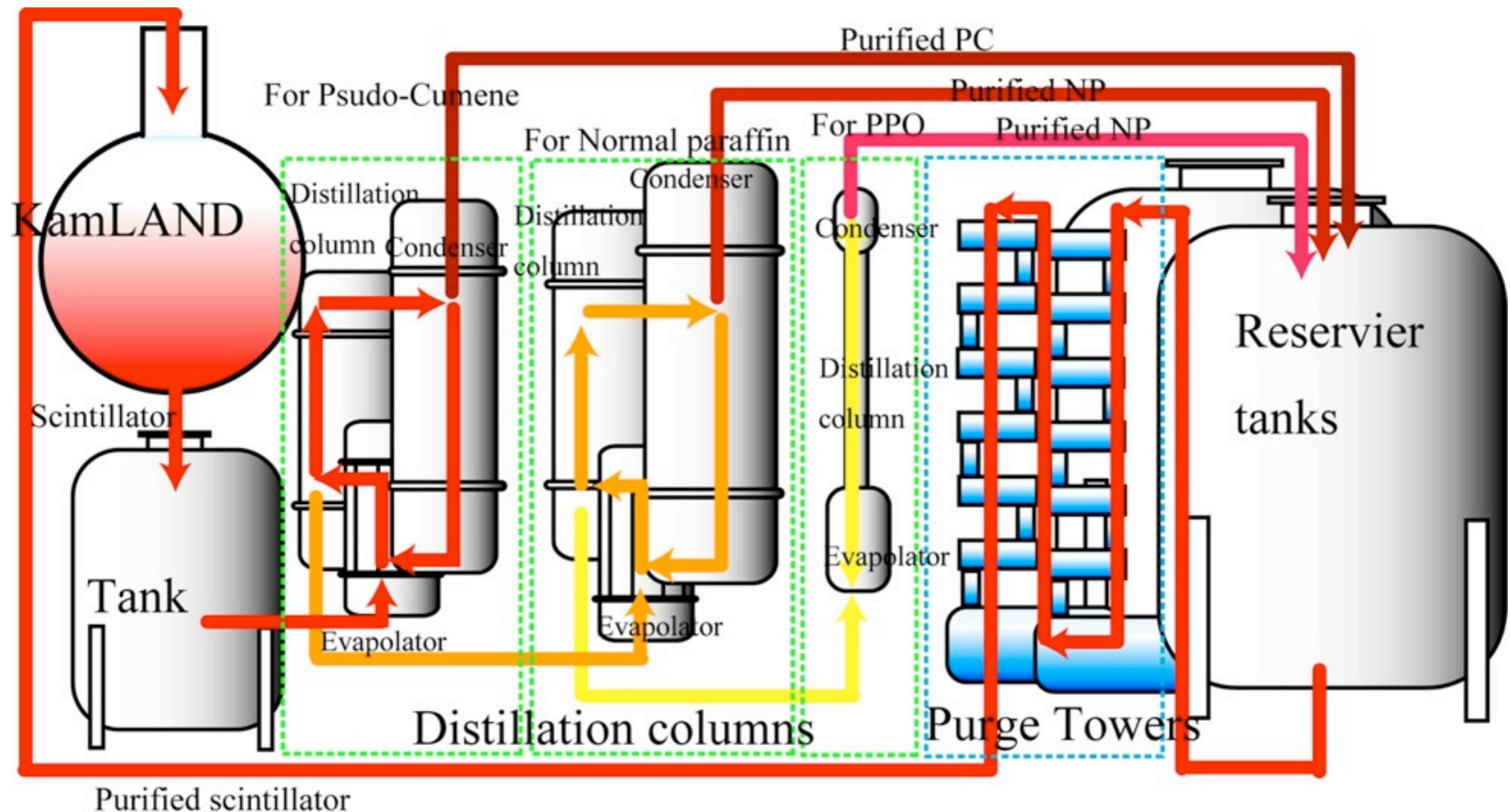


The Borexino Collaboration, arXiv:0808.2868 [astro-ph]

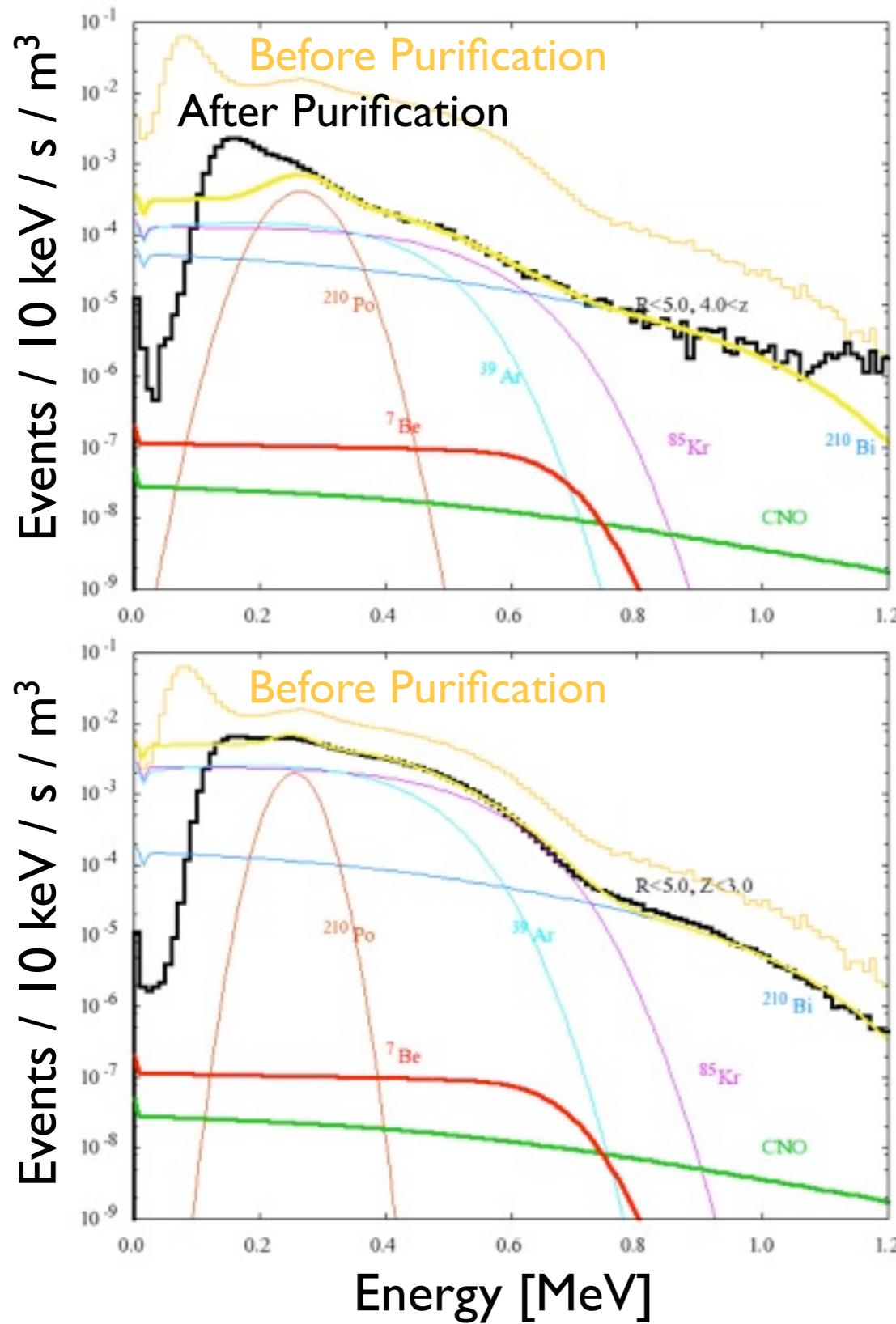
The Quest for ${}^7\text{Be}$ ν at KamLAND



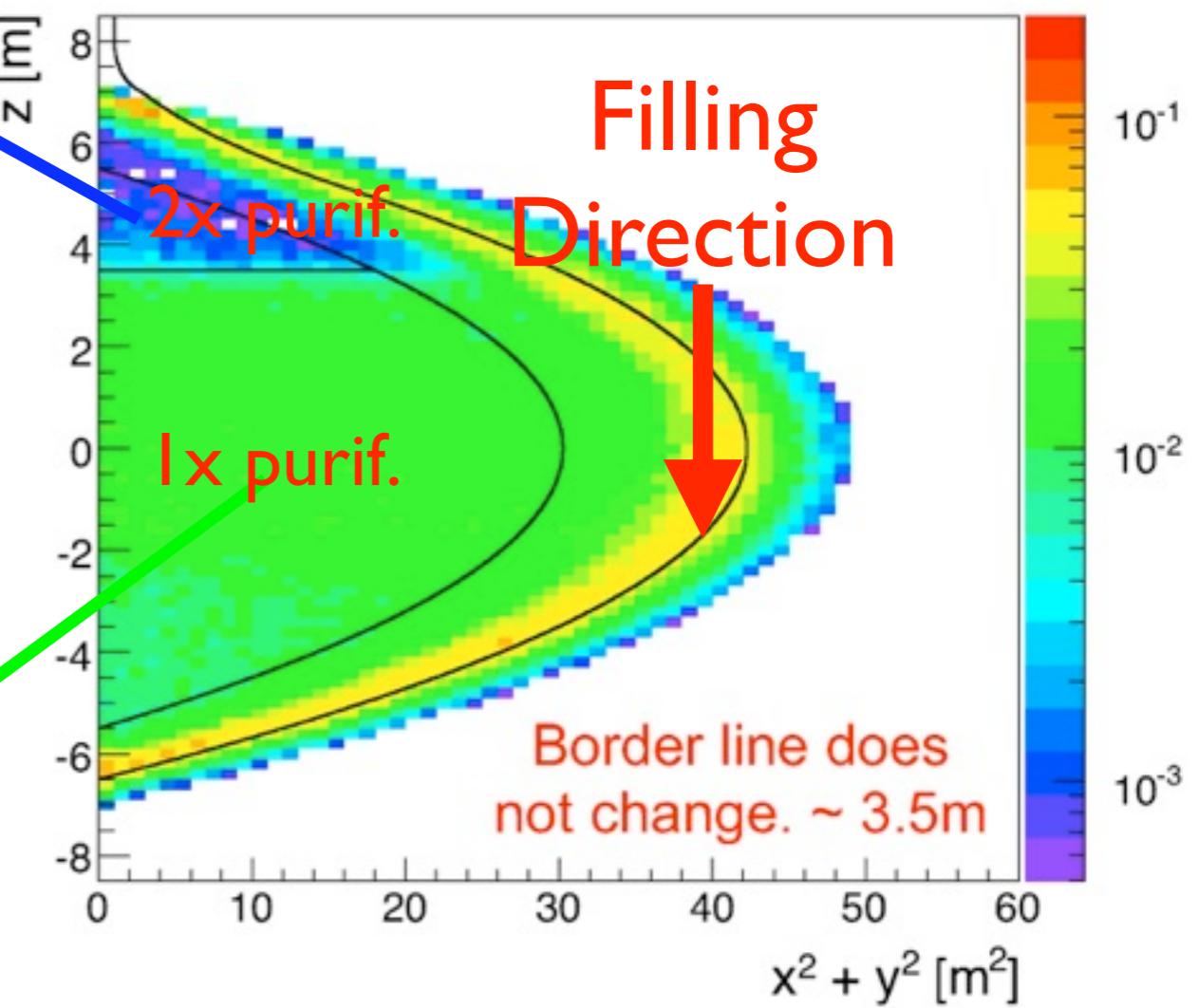
LS Purification



1st Purification Campaign

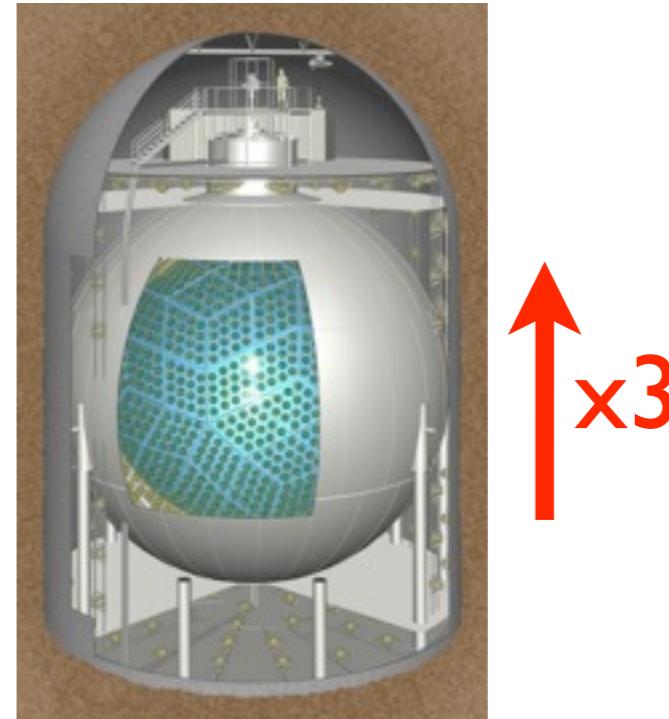
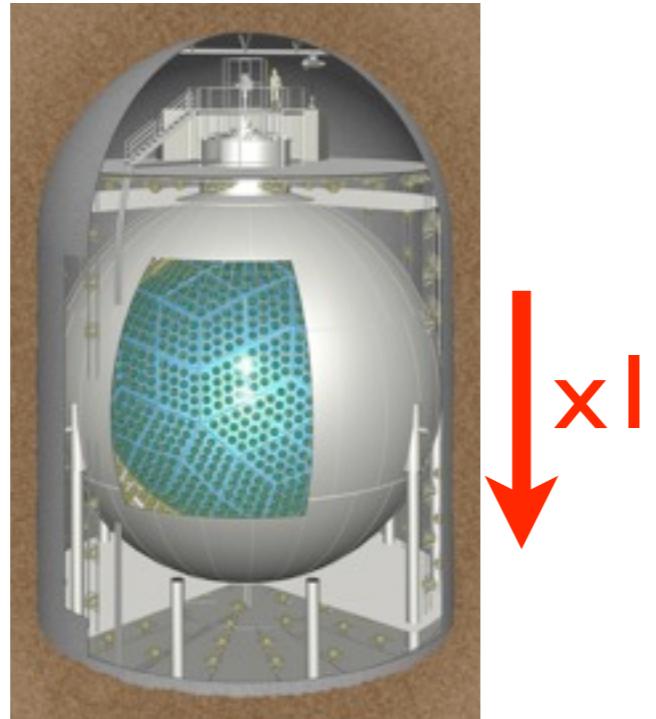


Summer 2007



2nd Purification Campaign

- Early 2008: many purification system upgrades during Kamioka Mine blasting
- Late 2008: ~4 more volume exchanges



- “Close enough” to our goals that I’m not allowed to discuss it further

KamLAND Publications in Progress

- Reactor + Geoneutrinos “long paper” / update
- ${}^8\text{B}$ spectrum
- Cosmic rays and cosmogenic activation
- Solar antineutrino update
- Several NIM papers
- ${}^7\text{Be}$? Stay tuned...